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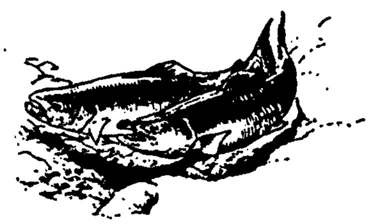

REGION ONE

C-047730

UNITED STATES DEPARTMENT OF THE INTERIOR

U.S. FISH AND WILDLIFE SERVICE
DIVISION OF ECOLOGICAL SERVICES
SACRAMENTO, CALIFORNIA

JUVENILE CHINOOK SALMON USE OF NEARSHORE HABITATS ON THE SAN JOAQUIN RIVER, CALIFORNIA

by

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Prepared for the
U.S. Army Corps of Engineers, Sacramento District
Lower San Joaquin River and Tributaries
Clearing and Snagging Project

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INTRODUCTION

This study was conducted by the U.S. Fish and Wildlife Service for the Sacramento District, Corps of Engineers. The purpose of the study was to assess habitat use by juvenile chinook salmon along three types of nearshore habitats that may be impacted by the Corps of Engineers' proposed Lower San Joaquin River Clearing and Snagging Project. Previous studies (USFWS, 1985) have quantified habitat losses and compensation needs of resident warmwater fish. This study was initiated in January 1986 but suspended in mid February of that year due to flood flows in the San Joaquin River. No juvenile chinook salmon were captured during the initial effort. In 1987, the study was redesigned and rescheduled. During this time, the Corps of Engineers decided to drop this lower San Joaquin River reach study from their proposed project due to other project-related problems. However, the Fish and Wildlife Service was requested to complete the study for potential future work within this reach.

The Lower San Joaquin River and Tributaries Clearing and Snagging Project includes channel clearing of the San Joaquin River from Friant Dam downstream to the City of Stockton. The purpose of the project is to alleviate localized flooding, seepage, and bank erosion along 225 river miles of the San Joaquin River. The original project was authorized by the Flood Control Act of 1944 with work beginning in 1956 and ending in 1972. The present proposal to clear and snag was authorized by an amendment to the 1944 Act: Section 205 of House Resolution 7245 of the 1983 Supplemental Appropriations Act.

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The San Joaquin River system once supported major runs of both spring and fall-run chinook salmon. Spring-run chinook salmon entered during the period of high spring snowmelt, remained in deep pools in the upper mainstem and tributary reaches during the summer, and spawned in early fall. With the onset of dam construction in the system prior to the 1930's, spring-run stocks (estimated to number over 100,000 annually) began declining. Following construction of Friant Dam in the 1940's, and eventual dewatering of the mainstem as far downstream as the Merced River, the spring-run was completely eliminated.

Fall-run chinook salmon enter the San Joaquin River system in the fall and spawn shortly after their arrival. Historically, fall-run chinook salmon spawned primarily in the mainstem San Joaquin upstream from the mouth of the Merced River and in all the major tributaries. Because of dam construction and subsequent water diversions for irrigation, the fall-run is now limited to the lower reaches of the three major tributaries: Merced, Tuolumne and Stanislaus Rivers. Total fall-run spawning populations in these rivers declined from over 100,000 fish in the early 1940's to less than 1,000 fish by 1977. Although the chinook salmon run has increased considerably since 1977, adverse impacts to the habitat continue to plague the salmon populations of the San Joaquin River.

STUDY AREA

The headwaters of the San Joaquin River and its major tributaries originate near the 9000 foot elevation on the western slope of the Sierra Nevada Range, approximately 135 miles due east of the San Francisco Bay Area. The rivers drain in a southwesterly direction from the Sierra's until reaching the floor of the southern San Joaquin Valley. Draining northward through the valley, the San Joaquin River meets the southward draining Sacramento River to form the Sacramento-San Joaquin Delta. The Delta waters flow into the Bay and constitute the area known as the San Francisco-Bay-Delta Region.

Six primary tributaries of the San Joaquin River drainage include, from north to south, the Stanislaus, Tuolumne, Merced, Chowchilla and Fresno Rivers and Kings River North. The tributaries have a total drainage area (excluding Kings River) of about 15,000 square miles, producing an average annual runoff of about 7 million acre-feet. As runoff leaves the Sierra Nevada, diversions, channel seepage and other water uses reduce the average annual outflow to about 3 million acre-feet at Vernalis on the lower San Joaquin River.

The area of the Lower San Joaquin River Clearing and Snagging Project includes 225 river miles of the San Joaquin River from Friant Dam downstream to Stockton. The study area is limited to 62 river miles between the Merced River confluence, downstream to Mossdale County Park (Figure 1). The confluences of the three major salmon producing tributaries: the Stanislaus, Tuolumne and Merced Rivers are within the boundaries of the study area.

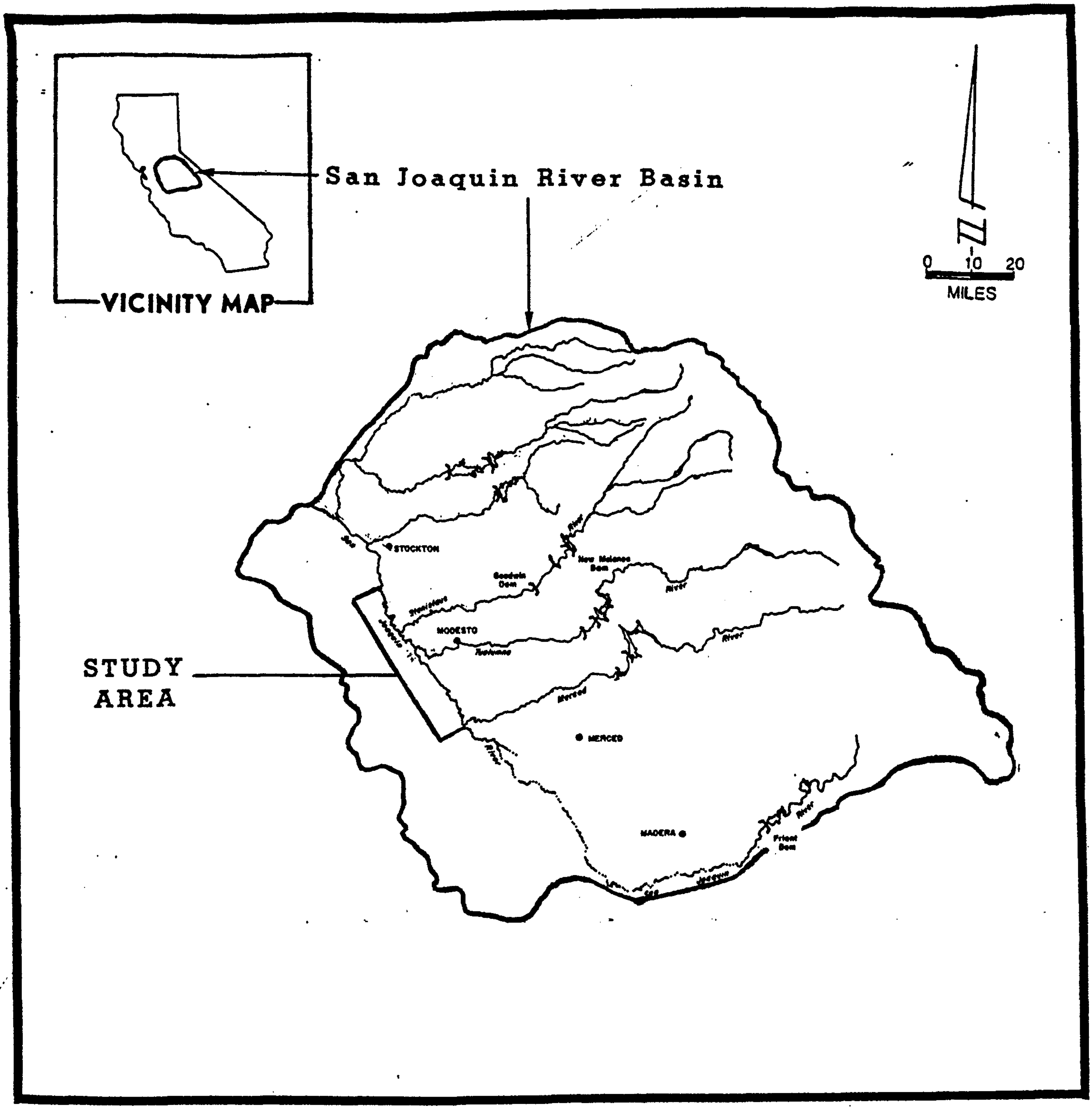

FIGURE 1. General location map of study area for juvenile chinook salmon nearshore habitat use data collection, San Joaquin River, California.

The San Joaquin River downstream of the Merced River is highly sinuous with a sequence of pool-run habitat. Riffles are completely lacking. The elevation ranges from 60 feet near the Merced River to sea level at City of Stockton. The average channel slope is about 0.8 feet per mile. Substrate is predominately sand and rich organic mud with small gravel present infrequently near the Merced River. Wide meanders and detached oxbows are present and support extensive patches of undisturbed woodland habitat. The riparian plant communities along the river are dominated by cottonwoods, willows, box elder, valley oak and sycamore trees, with an understory of willows, wild rose, blackberry, wild grape, elderberry and various perennial herbs and grasses. The dominant land use along the river is agriculture. In some areas, agricultural development on the floodplain occurs within the levee systems.

METHODS

Ten separate river miles were selected as sample locations along the San Joaquin River between the confluence of the Merced River and Mossdale County Park (Figure 2). Within each river mile, three types of shoreline habitats were identified and sampled for a total of 30 sample sites. The habitat types sampled are described as follows:

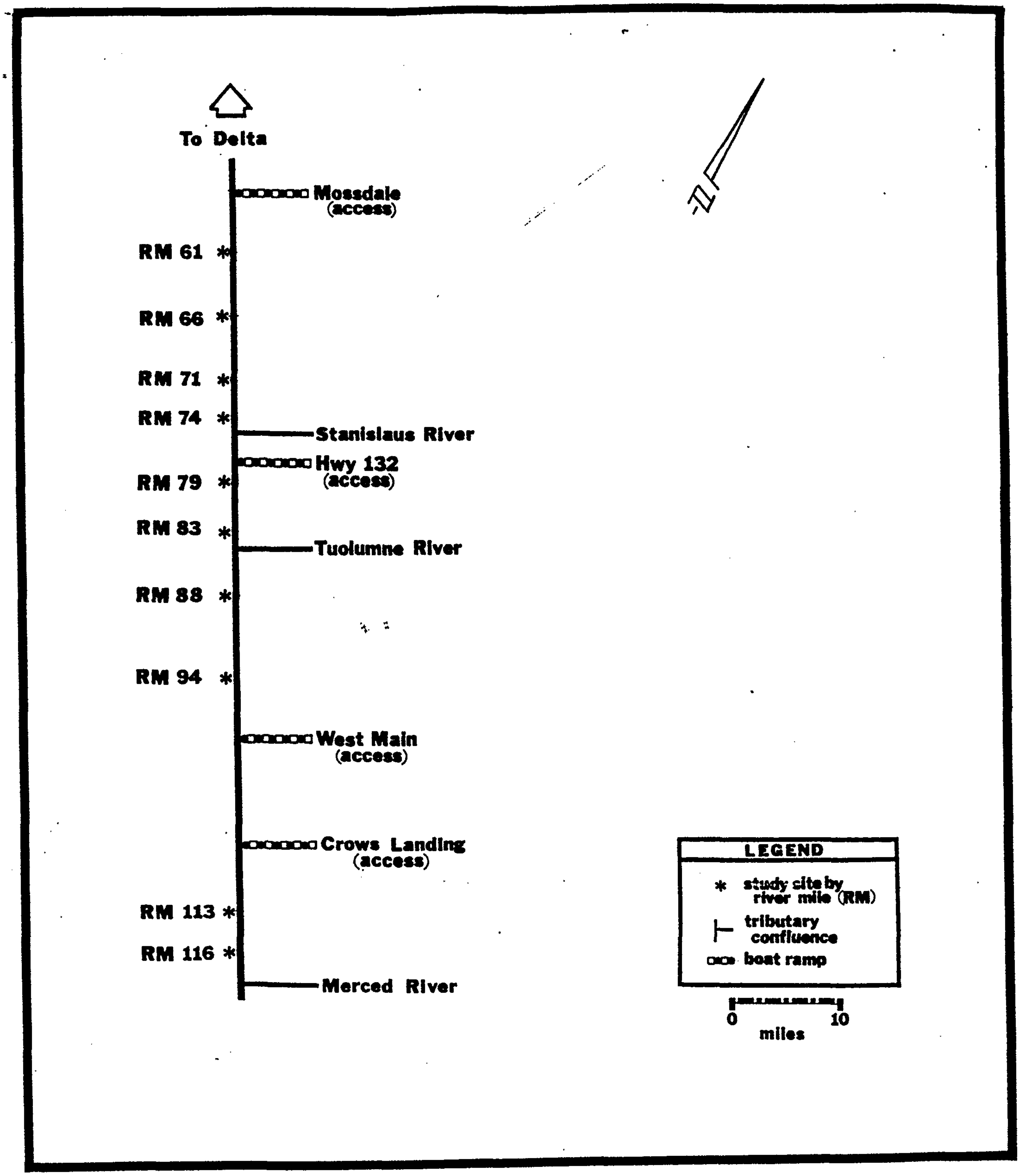

FIGURE 2. Schematic diagram of study site locations used for collection of juvenile chinook salmon nearshore habitat use, San Joaquin River, California.

(1) Sandy points - a shoreline reach composed primarily of sand and generally lacking any vegetation within 50 feet of waters edge. Instream cover (woody or vegetative) generally lacking;

(2) Non-woody riparian - a shoreline reach composed primarily of sand with various forbs and grasses the dominant plant species. Woody vegetation generally lacking within 50 feet of waters edge. Instream cover (woody or vegetative) generally lacking; and

(3) Riparian - a shoreline composed primarily of sand and other organic material with cottonwoods or willows. Woody vegetation generally overhanging the waters surface, instream cover (woody debris) usually present sporadically along waters edge.

Representative sites of these three shoreline habitat types are presented in Figure 3 (a,b & c).

The ten river miles chosen for sampling were selected 1) to represent the three natural shoreline habitats found between the major spawning tributaries that could potentially be altered by the proposed project, 2) to optimize sampling strategy by limiting travel time involved between sample sites and boat access points, and 3) to ensure one of each of the shoreline habitats under evaluation could be sampled within a single river mile.

(a)

(b)

(c)

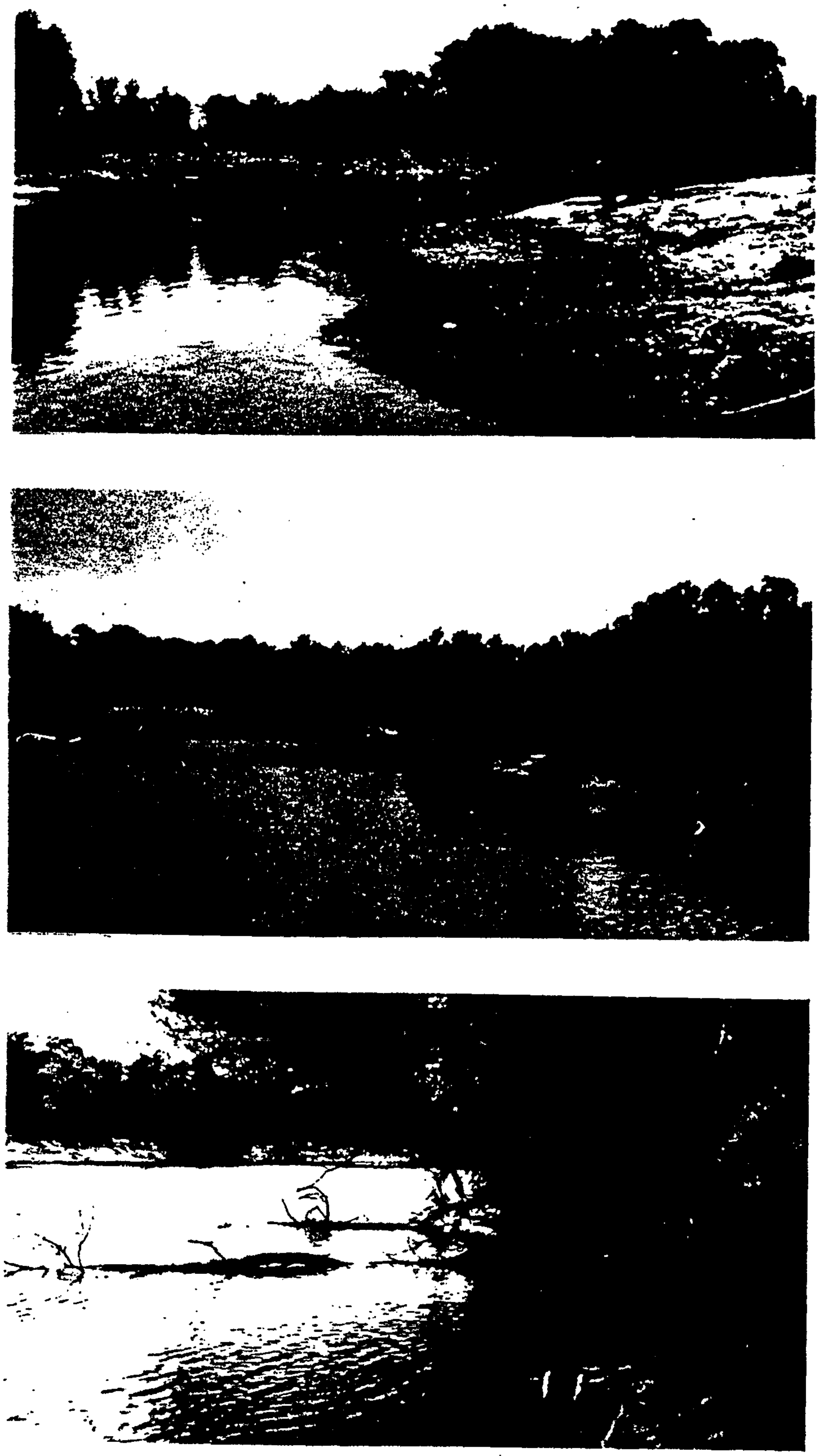

Figure 3. Representative sites of sandy point (a), non-woody riparian (b), and woody riparian (c) habitat types used for assessing nearshore habitat use by chinook salmon, San Joaquin River, California.

All sampling was conducted over a seven week period beginning the week of February 15, 1987 and ending the week of April 26, 1987. Sampling was limited to three days during alternate weeks with the exception of the last three consecutive sample weeks in April. Two delta 1/8 inch stretch mesh bag seines were used to sample each site. Depending on water depth and sample area, either a small seine (25 feet long by 4 feet deep) or a large seine (50 feet long by 4 feet deep) was used. Electrofishing using a boat and backpack shocker was also tried; however, sampling was hampered by poor water visibility, high water conductivity and subsequently, unsuccessful capture of small juvenile chinook salmon.

At each of the sample sites, one seine haul was made in the downstream direction parallel to the shoreline. When juvenile chinook salmon were captured, they were collected from the seine and placed in a one-gallon bucket. Captured fish were enumerated and measurements taken to the nearest millimeter. Coded wire tagged salmon (indicated by an adipose clip) were also noted. General information recorded at each site included: (1) sample date and time, (2) sample site (by river mile), (3) shoreline habitat type, (4) air and water temperatures, (5) name of observers, (6) length and width of sample area, (7) water visibility (from secchi disk readings), and (8) water depth and mean water column velocity (taken at 0.25, 0.50 and 0.75 of sample width at midpoint of sample length).

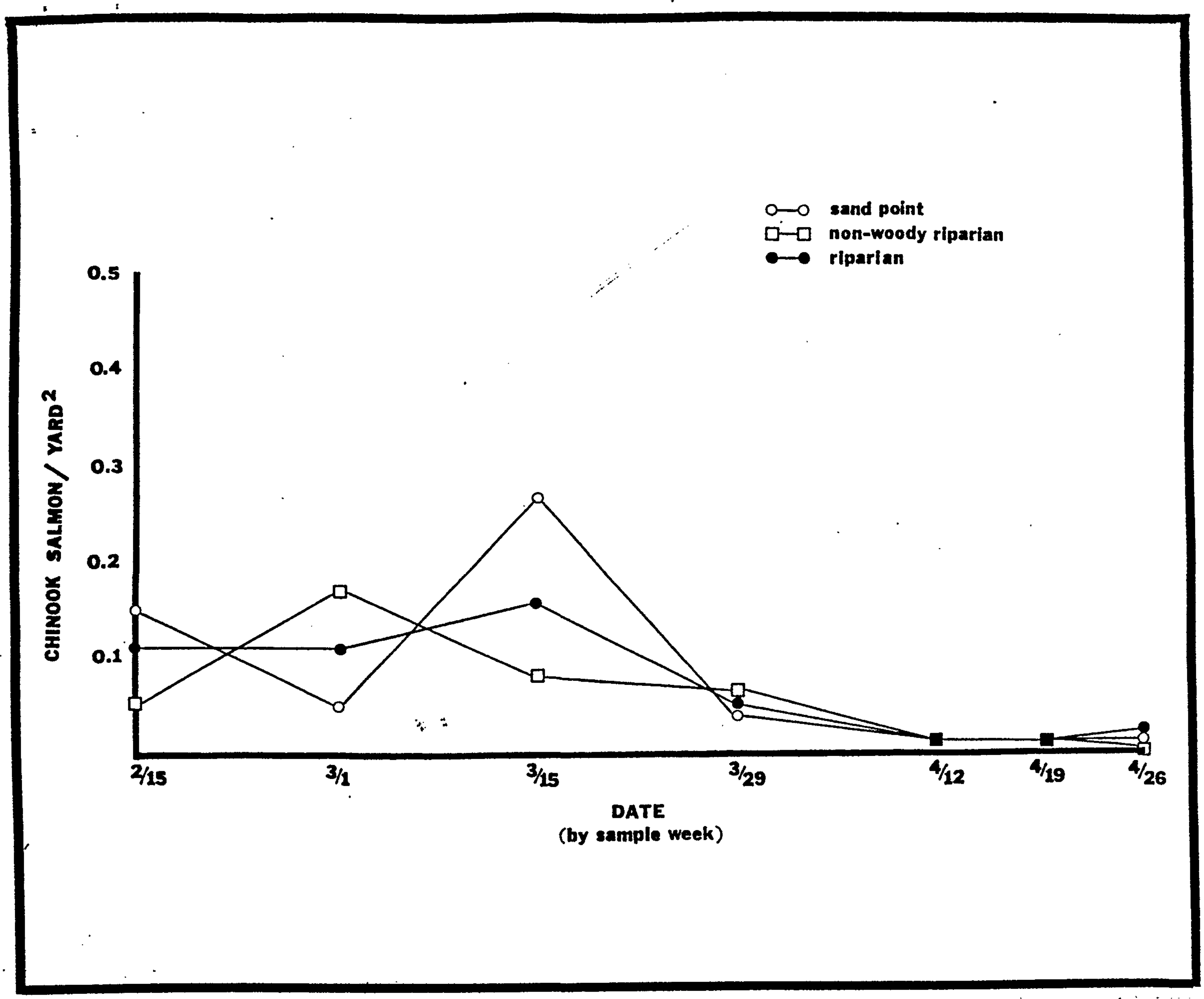

FIGURE 4. Average weekly number of juvenile chinook salmon captured per square yard at sand point, non-woody riparian and riparian nearshore habitat types during seven sample weeks from February 15, 1987 to April 26, 1987, San Joaquin River, California.

RESULTS AND DISCUSSION

The weekly average catch of juvenile chinook salmon collected from February 15, 1987 to April 26, 1987 is presented by habitat type in Figure 4. Salmon catch peaked in all habitats around the March 1 and March 15 sample periods and dropped to a constant low through the end of April. The highest weekly average catch was 0.27 salmon per square yard observed at the sand point habitat (March 15 sample week). Salmon catch for this sample period is largely represented by a single highest catch of 1.27 salmon per square yard collected in the back eddie of a sandy point downstream of the Stanislaus River. This peak in catch may be the circumstance of fish displaced into the San Joaquin River as flows increased in the Stanislaus from 600 cubic feet per second (cfs) to 1,250 cfs over a 24 hour period, one day prior to sampling. Overall, however, catch throughout the study appeared relatively low with only 1,112 total fish captured for 34,200 total square yards sampled.

An analysis of variance (Appendix A) using a square root transformation (Sokal and Rohlf 1973) indicates that juvenile chinook salmon habitat use of sandy points, non-woody riparian, and riparian banks on the San Joaquin River does not differ significantly (P = 0.05). Based on literature review, however, it is expected that salmon habitat use would be significantly greater in the nearshore riparian habitat where instream and overhead object cover is most abundant.

Previous studies have identified cover, in the form of riparian vegetation, rocks, turbulent waters, logs, woody debris and undercut banks as an important stream habitat component for fish (Chapman and Bjornn 1969; Lewis 1969; Meehan and Platts 1976; Reiser and Bjornn 1979; Platts 1981). Reiser and Bjornn (1979) suggest that cover is perhaps more important for salmon during rearing than at any other time because this is when they are most susceptible to predation. Cover not only provides refuge from predators but also acts as velocity shelters where fish can rest (Bustard and Narver 1975) and move to feed on nearby drift food organisms (Lewis 1969). According to Chapman and Bjornn (1969), both the quantity and quality of cover greatly determines salmon distribution.

When conditions permit, visual observation is the most effective method for assessing habitat use of juvenile salmon. This is particularly true in areas with instream object cover, where active netting methods can snag and render a sample invalid. In the San Joaquin River, where cover is primarily in the form of riparian vegetation, logs, woody debris, and to a lesser degree, undercut banks, poor water quality and water visibility (0.5 - 1.6 feet) precluded use of visual methods. Seining, therefore, was selected second to direct visual observations. Because of the difficulties just discussed, sampling the riparian sites was limited to smaller areas with little or no instream objects. Thus, by the end of our study, the riparian habitat represented only 21% of the total area of all sites sampled while sandy points represented 44%. Additionally, as water levels in the river dropped over the duration of the study, the interface between waters edge and riparian habitat greatly diminished at some sites. Clearly, riparian habitat was under represented in both quantity and quality. The sampling limitations and river discharge may have influenced our results.

Based on the habitat use observed, we believe parameters other than the type of nearshore habitat may have a greater influence on juvenile salmon distribution and abundance in the San Joaquin River. Although instream conditions, such as water quality and river discharge, are factors that affect juvenile salmon distribution (and survival) in the San Joaquin, this study was not designed to assess the multitude of influencing factors. For purposes of this report, we merely present the findings and discuss three parameters: water velocity, depth, and temperature. They were measured in our study and are documented in the literature to influence salmon habitat utilization.

Sampling sites were selected where water velocities were not so great as to impair the effectiveness of seine hauls. Average velocities at the study sites ranged from 0.1 - 1.7 feet per second and remained constant throughout the study period. Because of the velocity limitation, sampling did not allow for changes in salmon distribution (habitat utilization) as velocity requirements changed for the fish. Salmon, which are opportunistic feeders, need velocities to bring them food. Higher water velocities (to a point) are necessary to provide more food items as the fish grow (Chapman and Bjornn 1969). Thus, if larger salmon required higher velocities outside the range of velocities at our study sites, by nature of our study design, the salmon distribution would not be reflected in our results. According to Lewis (1969), water velocity and cover probably have the most influence on distribution of some salmonids. Ideal conditions are created when these two factors combine to provide a place of refuge and a velocity break next to a rapid velocity vector (Lister and Genoe 1970).

Water depth may be another parameter which influenced salmon distribution during our study. According to Bjornn (1971), depth influences both the distribution and size of salmon found in a particular area. Based on seining surveys in the Stanislaus River, Neilland (personal communication) reports juvenile chinook salmon begin utilizing more of the water column as fish reach 65-85 millimeters (mm) in fork length. Other studies in the Stanislaus River (Aceituno, personal communication) and Sacramento River (Hoffman and Deibel 1984) found chinook salmon fry, less than 50 mm fork length, utilize a narrow range of shallow depths while larger salmon occupy deeper water.

In our study, the average fork length of salmon captured increased from 44 mm (February 15 sample week) to 70 mm (April 26 sample week). During this same time, overall catch per unit area decreased. This decrease in catch may be a result of the larger fish utilizing deeper water outside the narrow range of depths available in our nearshore study areas. The average depth at our study sites ranged from 0.6-2.2 feet; thus, any larger fish utilizing deeper waters would not be captured.

Because fish are cold-blooded organisms, their physiological functions, behavior and performance are strongly influenced by water temperature. Water temperature influences their growth rate, swimming ability, availability of dissolved oxygen, ability to capture food and ability to withstand disease outbreaks (Reiser and Bjornn 1979). Temperature, therefore, may be the most critical factor determining the distribution and abundance of fish in a given system.

According to Reiser and Bjornn (1979), salmonids prefer a narrow range of temperatures in which to live, and hence, temperatures may help regulate fish density. Fish are able to sense very slight temperature changes (Bardach and Bjorkland 1957), thus, they will seek a thermal environment that minimizes physiological stress and maximizes their growth and fitness (Brett 1952; Magnuson et. al. 1979).

In our study, water temperature appeared to be the most influencing factor affecting chinook salmon catch. The observed decrease in catch after the March 15 sample week, in all habitats, corresponds to increased water temperatures (Figure 5) above the preferred range for juvenile chinook salmon rearing (Reiser and Bjornn 1979). Through April, temperatures in the nearshore habitats downstream of all tributaries were within lethal limits. In response to the temperature regime observed in the nearshore habitat, we believe one or more of the following situations occurred:

1) Fish sought deeper water of cooler temperatures (if available) outside the sampling sites;

2) Fish migrated quickly through the system entirely; and

3) An unknown percentage of the fish died from exposure to lethal temperatures.

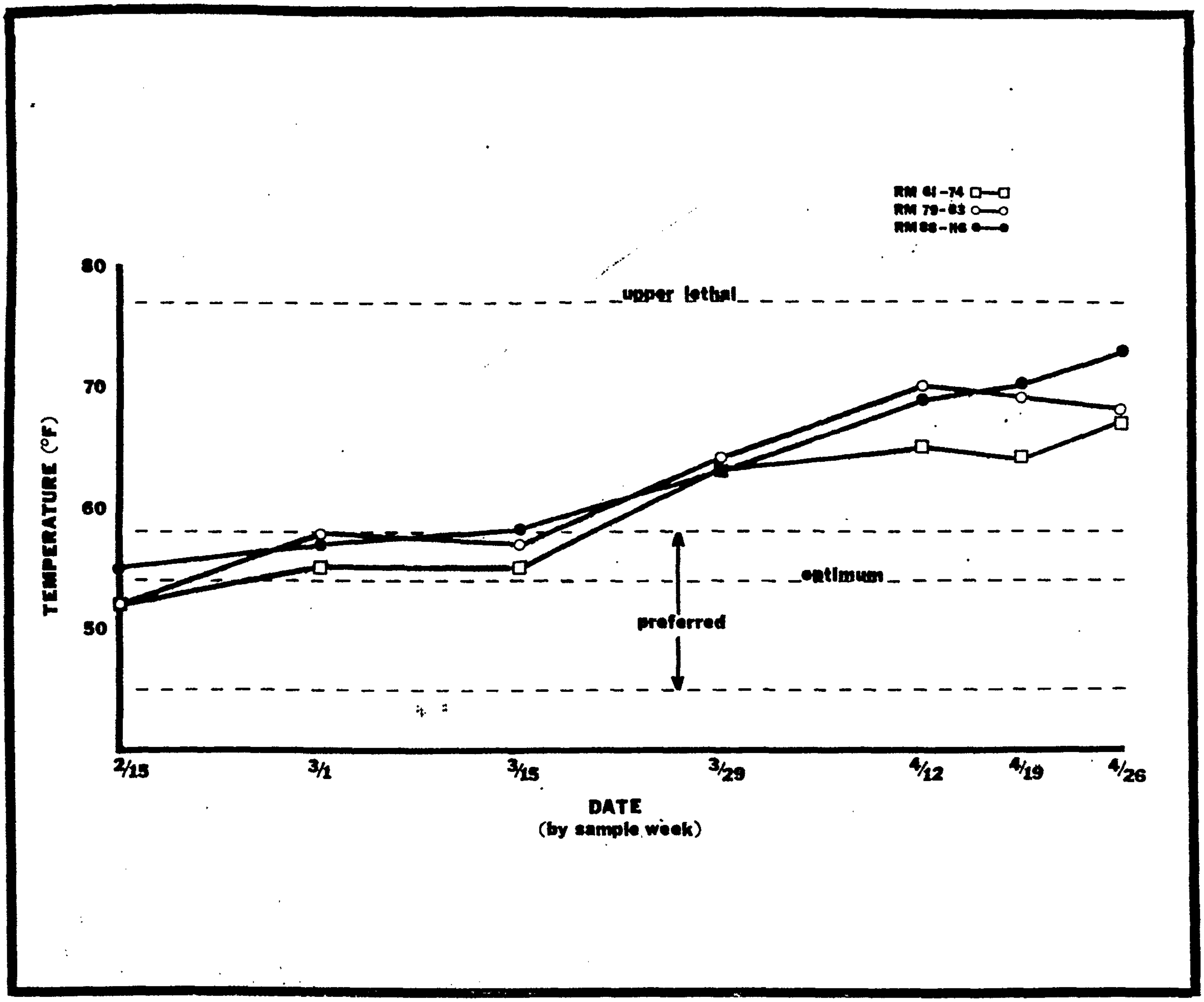

FIGURE 5. Average weekly nearshore water temperatures recorded downstream of the Merced, Tuolumne and Stanislaus confluences during seven sample weeks from February 15, 1987 to April 26, 1987, San Joaquin River, California.

Although any one or all of the above situations may have occurred, it is beyond the scope of this study to assess their relative impacts on the results of our study.

In a final note, the importance of riparian habitat on stream temperature should be recognized. According to Lantz (1971), the thermoregulatory functions of riparian vegetation can have a profound influence on the survival and distribution of juvenile salmonids. Clearing of riparian vegetation increases water temperature and together with the loss of tree root habitat, can cause dramatic reductions in fish production (Ringler and Hall 1975). If in fact the high water temperatures experienced during our study are adversely affecting the distribution and abundance of salmon, the removal of riparian habitat will only compound the problem.

CONCLUSIONS

The results of this study indicate that juvenile chinook salmon use of sandy points, non-woody riparian and riparian bank habitat on the San Joaquin River does not differ significantly. However, we believe the results of this study do not provide a true analysis of bank habitat use by juvenile salmon. This belief is based on gear and sample limitations, literature review, and personal experience. Our experience on the Stanislaus, American, Sacramento and Trinity Rivers, using direct in-water visual observation, indicate that juvenile salmon in many cases are more abundant in areas of cover (overhead, instream object and bottom). Should a refined study of this nature be continued for a number of years, the results would likely alter significantly favoring areas with abundant cover.

The Service previously conducted a Habitat Evaluation Procedures for aquatic resources (USFWS, 1985). In that study, habitat variables were measured and included percent bottom cover, percent total cover and percent inundated vegetative cover. The Habitat Evaluation Procedures study was designed to quantify the impacts of clearing and snagging nearshore habitat for warmwater fish. Compensation requirements were also identified in that study.

It is our belief that these same compensation requirements of replacing habitat units lost would, in fact, also provide the necessary compensation for loss of near bank habitat used by juvenile chinook salmon. Velocity ranges and water depth with the project are not likely to change from existing baseline conditions of the project, since all work was proposed up to the waters edge.

Water temperature appears to be a critical factor for juvenile salmon in nearshore habitat within the project area. Temperatures in nearshore habitat downstream of the tributaries were within lethal limits. Approximately 53 sites, totalling 52 acres, had been proposed for clearing. The linear length of clearing represented approximately eight percent of the total bank habitat available, including riprapped areas, within the reach. A number of previous studies conducted by the Service and others along the Sacramento River indicate low rearing habitat values for juvenile salmonids on riprapped banks (Michny, personal communication). The total length of riprapped banks in the reach was not calculated. The clearing of the 53 proposed sites alone would probably not significantly impact juvenile salmon. The cumulative impact to juvenile salmon from this proposal coupled with other activities along the river or a larger clearing and snagging proposal would lead to higher water temperatures and an increase in impacts to juvenile salmon in nearshore habitats.

Two questions need further investigation. The first is whether or not there is deeper, cooler water available outside the nearshore sampling sites, and secondly, whether or not the salmon migrate quickly through the system or die from exposure to lethal temperatures.

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APPENDIX A

Analysis of variance using square root transformation for juvenile chinook salmon captured at sand point, non-woody riparian and riparian nearshore habitat types, San Joaquin River, California.

Source of Variation	df	SS	MS	FS
Among Stations	2	0.01	0.01	0.18 1/
Within Stations	189	7.20	0.04	
Total	191	7.21		

1/ not significantly different at the 0.05 level

df = Degrees of freedom

SS = Sum of Square deviation

MS = Mean of Square deviation

FS = Fishers F statistic